The HELP Clinical Decision-Support System

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Editor's Note: *This article is geared to the future when physicians' offices will be linked to hospital computer systems with interactive capabilities.*

This paper outlines an approach to hospital decision-making systems and data collecting capabilities which will allow office-based physicians to access hospital records and systems. Ultimately it will be possible to monitor a patient in the hospital from a physician's office.

ABSTRACT

This paper describes the innovative and state-of-the-art hospital information system in development and use at LDS Hospital in Salt Lake City. The system, called HELP, is an "expert system" with built-in decision-making capabilities. It integrates computerized medical records with patient information drawn from many clinical centers.

The HELP system has been used to improve patient care and clinical decision support. It has helped to detect adverse drug events, facilitated continuous quality improvement application, and minimized iatrogenic illness by providing computerized decision support.

The author provides insights on the development process and the overall goals and revision of the HELP's medical informatics development group. These may help other hospitals overcome obstacles during their own information system development process.

Key words: Clinical decision-support systems; medical informatics; automated/computerized patient records; decision-making support systems; medical computing; hospital information systems.

THE NEED FOR TIMELY INFORMATION

The ultimate purpose of a medical record, be it handwritten or computerized, is to provide data so physicians and other care givers can make timely and accurate medical decisions. Along the way, the medical record must also serve other purposes such as providing an "audit" trail for the care process and generating a record for billing.

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Recently, the Institute of Medicine declared that a computer-based patient medical record was an essential technology for health care.[1] Hand-written paper medical records are limited in their ability to assist in alerting or advising physicians, nurses, or other health care professionals. As a result, in most hospitals, multiple strategies are used to get time-critical information to health care decision-makers. For example, phone calls or electronic pagers may be used. Reporting systems in most hospitals are "batch" systems. For example, nursing reports are finalized at the time of nursing shift changes; chemistry results may be reported after all the tests are completed, etc. As a result of this "batch" mind set, many times patient care is compromised.

AN INTRODUCTION TO THE LDS SYSTEM

LDS Hospital is a 520-bed, private, tertiary care hospital and a major teaching center for the University of Utah School of Medicine. It is located in Salt Lake City. At LDS, much of the patient's medical record is computerized. A considerable amount of the patient's medical record is obtained by automated means and stored in the HELP computer system.[2,3] The HELP hospital information system has been under development for the past 20 years. HELP is an integrated, clinically-oriented system that has medical decision-making capabilities. Daily clinical operation of the LDS Hospital is now dependent on the HELP computer system. A key feature of the HELP system is its integrated computerized medical record that contains patient information from

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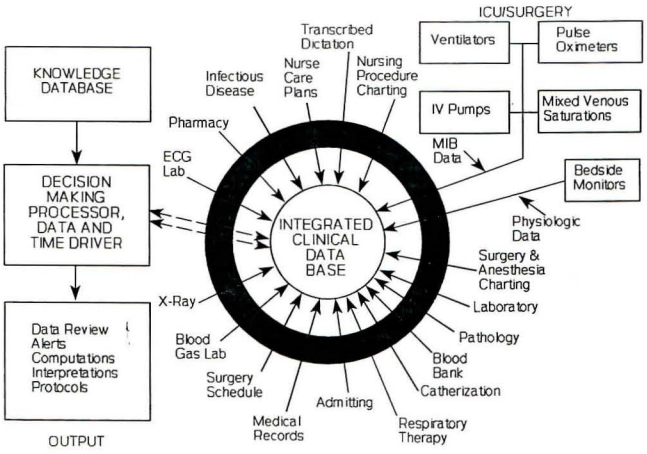

Figure 1. Schematic block diagram of the HELP system. The central database is shown in the middle. Data flow from many clinical data sources is shown by the inward pointing arrows. As the data flows into the database it passes through a dark "stippled" area. This area is schematic of the "data" drive capability of the system. As data flow in from the various sources, knowledge from the system's expert system is applied to the data to determine if alerts or therapeutic suggestions should be made.

clinical areas such as the laboratory, pharmacy, nursing, surgery, intensive care, medical records and other locations (See Fig. 1). In addition, the HELP computer system is an "expert system" and has built-in decision-making capabilities.

IMPROVING PATIENT CARE

McDonald and Eddy have clearly shown that humans are ***not*** perfect information processors.[4-7] In fact Eddy made the statement " . . . All confirm what would be expected from common sense: the complexity of medicine exceeds the inherent limitations of the unaided human mind."[7] Computers should be able to assist in the medical care process.

The HELP system has been used to improve patient care in several clinical areas. Examples of how the HELP system has been used in clinical decision-support include:

■ **Detection of Adverse Drug Events (ADE).** The system has been used to monitor laboratory test results, medication orders, and sources of clinical data to detect more than 80 times the number of ADEs previously found.[8] As a follow-up to the ADE system development, we are now using the HELP system to prevent ADEs and minimize their seriousness by using "real-time" problem detection and follow-up.[9, 10]

■ **Facilitating the Application of CQI.** Continuous Quality Improvement (CQI) principles have been applied using the HELP system as the data source. It is increasingly recognized that the elimination of unnecessary variation in clinical care has the potential to improve the quality of care and can lead to prevention of adverse events. Development of clinical epidemiological techniques allows investigators to identify variations in care and intervene when necessary. Intensive surveillance and analysis of variations with feedback to providers can reduce the rates of adverse patient outcomes. However, cost-effective surveillance and intervention requires timely access to all the patient data.

The computer-based medical record provided by an integrated hospital information system allows clinicians to acquire, process, manage, and store clinical data on all patients in a more efficient and usable form. Computer-based medical records provide the necessary tools to identify and reduce unnecessary variation in clinical care by eliminating the information acquisition, processing, and action element missing in most hospitals today. Clinical computer systems enable health care providers to identify and monitor known relationships between clinical events and patient outcomes for both good and bad events.[10]

■ **Minimizing Iatrogenic or Hospital Acquired Illness.** Iatrogenic illness is a major factor contributing to negative patient outcomes. These negative outcomes include morbidity and mortality. A recent study demonstrated that the most common adverse events in hospitalized patients are drug-related.[11] Careful studies have demonstrated that most of the ADEs were a result of drug dosing errors. Recent studies done at LDS Hospital have shown that ADEs were poorly reported before computerized mechanisms were put in place to detect them. Now methods are in place to prevent and more quickly detect ADEs so their adverse effects can be minimized.

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■ **Providing Decision-Making Support.** Computers have been demonstrated to assist physicians in decision-making. The human mind has inherent limitations and can be subject to data overload.[4] Since humans are imperfect information processors and clinical medicine is a very information intensive industry, it is no wonder that mistakes are made. It is unrealistic to believe that the unaided human mind can accurately synthesize all the necessary pieces of patient-specific laboratory and other findings along with all the pharmacology and modeling to detect every potential problem. Take, for example, the prescription of the antibiotic Imipenem.[9]

At least 32 factors must be taken into consideration as Imipenem and its dosage are considered including: drug ordering; drug administration; specific patient factors; physiological factors; and pharmacologic factors.

■ **Aiding Infection Control.** Hospital infection control and surveillance is typically a manual process. However, computerized infectious disease monitoring is done much more efficiently and effectively. More appropriate prophylactic antibiotic administration before surgery has dramatically reduced surgical wound infections.[12–16]

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■ **Providing Treatment Protocols.** One of the more recent and exciting projects developed on the HELP system relates to protocol control of patient ventilation. Patients with adult respiratory distress syndrome routinely have their ventilator settings adjusted based on computerized recommendations.[17, 18] As a consequence of developing these treatment protocols there is less variation in the care process and survival has improved from 9% to over 40%.[18] We have also found that in addition to survival improvement, there has been a desire on the part of the medical staff to develop consensus standards and guidelines to provide care for other patient care processes.[17, 18]

LESSONS LEARNED

In the process of developing the HELP system we have learned numerous "untold" lessons. These include the following:

Lesson 1: Make reasonable *compromises.* Like every group of developers of medical computing systems, we have learned more about how *not* to do things perhaps at a greater velocity than we have learned *how* to best do them. To give an example of a compromise, our clinicians indicated that they wanted very rapid patient data review capability. To achieve fast response speed, we have designed a data base that is time and "patient" oriented. Unfortunately, searching the same data base is not particularly fast when someone asks us to perform a search of all the patients in the hospital who have had a serum potassium of greater than 5.6.

Lesson 2: *Collaboration* with clinical colleagues is crucial in the development of a clinically-useful system. Being physically "onsite" so that we can interact with our fellow colleagues and jointly work through problems has been crucial in developing a working and worthwhile system.[19] Also a joint level of trust between clinicians and medical informatics professionals seems to be an important attribute of our system development success.

Lesson 3: Medicine is much more *complex* in its social structure and application of scientific results than any of us estimated. We feel that if we can develop a clinical computer application after only 3 or 4 attempts, we have been very successful. As many have noted, medicine has not developed standards or even guidelines for much of what is done clinically. As a result, those of us in the medical informatics field must help move the standards development process along. At times we find we are using the computer to do the wrong thing exactly right.

Lesson 4: Developers of hospital information systems as well as those who use such systems must be *self critical.* Many times, ideas that sound good are terribly inefficient and do not serve the clinical community well.

Lesson 5: Having a computerized clinical database provides interesting and exciting capabilities.[15] However, if the data collected are not used for routine clinical patient care, the data stored in the computer is of marginal value. We talk about humans having athletic skills: "that they have to use it or lose it." We can make a similar statement about data stored in a patient record: "use it or confuse it." The data will not generally be accurate unless there is a *continued dependence on and checking of the information stored.*

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Lesson 6: *Integration of data from a wide variety of sources* into a computerized medical record is worth more than the "sum of the individual parts." For example, having data from a pharmacy computer application along with laboratory data can provide much more accurate and helpful alerts to pharmacists, clinicians, and laboratory staff.

Lesson 7: *Incremental development and implementation* of medical computing applications have been successful. In the process of gaining the confidence level of the clinical medical staff, we have been able to better serve our clinical constituents.

Lesson 8: *Integration of clinical computing into the daily workings of a hospital* is probably 80% a social experiment and only 20% a scientific venture.

The traditions and daily practices of medicine are hard to change. Careful interaction of medical informatics professionals with key medical staff and feedback are crucial to developing systems.

Lesson 9: *Computer hardware technology is moving so rapidly* that by the time a clinical application can be developed there will be new equipment that will make it better. However, waiting until everything is "perfect" before starting is a mistake. Assuming that there will be a "big bang" installation of the perfect medical computing system is a "pipe dream" for at least another decade.

Lesson 10: *Standards development* will make the development and integration of medical computing systems much easier and more efficient. One of the major obstacles to establishing a computer-stored medical record is the lack of "standards" that permit government, care providers, insurance companies, and medical computer system developers to share patient data easily.

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Lesson 11: A purely "free-text" computerized record will limit the *power of medical computing.* Today some hospitals are developing what they call an "electronic" medical record by reporting data in "free-text." To some people, free-text electronic mail constitutes an electronic medical record. While free-text electronic mail has its place in the modern hospital record system, it is only when the data are "coded" to have distinct meaning both to the people reading it, and to the computers processing it, that we have met the ultimate needs of the modern electronic medical record. Exclusive use of free-text constrains the utility of computerized medical records because it assumes that only humans will make medical decisions based on the data transmitted. An implicit assumption we make when we generate paper records and store only "free-text" data is that the physician, nurse, or other health care professional can and will provide *all* the necessary intellectual analysis of the patient data.

Lesson 12: Computers *can* be very beneficial in aiding clinical care providers with *expert critiques and consults, and in providing directions.* The *quality of patient care can* be improved by using medical computing. Medical diagnostic and treatment decisions have traditionally been considered to be artful, yet intuitive and scientific processes. In recent years, however, formal methods for decision-making have been applied to medical problem solving, and computer-assisted medical decision-making is gaining wider acceptance. For example, computers can be used to interpret a patient's ventilatory status based on blood gas laboratory data reports. Computers can also be used to alert physicians, nurses, or pharmacists when a medication may be contraindicated. Computers can also be used to provide physicians guidance by using computer-driven patient treatment protocols.

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Lesson 13: Lack of "*vision*" as to what clinical computing systems can do is the primary reason that computerized expert systems have not been more widely disseminated. In some recent interviews with our key clinical staff, this issue was repeatedly reported as limiting further system implementation.[19]

CONCLUSION

It is the goal of the developers of the HELP System to incorporate the mission outlined by the Institute of Medicine's computerized patient record into the planning and development of the computer-based patient medical record for the HELP System.[1] The mission is to:

1. Support the effective, efficient use of computer-based patient information in patient care, health care policy making, clinical research, health care financing, and continuous quality improvement;
2. Educate change agents and stake-holders (including the general public and health professionals) about the value of computer-based patient medical records in improving health patient care;
3. Foster the computer-based patient medical record as the primary vehicle for collecting patient data; and
4. Promote the development and use of standards for computerized patient medical record security, data content, structures and vocabulary.

At a recent retreat, the Department of Medical Informatics at LDS Hospital and our clinical colleagues established the following vision statement for the next decade. We are fully committed to be focused on the basic principle that *the department's primary purpose for existence is to improve the quality of patient care locally,* throughout the nation, and the world. We feel this can be accomplished through the development of a health care information system that would:

- Use state-of-the-art technology to establish a friendly interface between computers, patients, and health care workers, providing a hassle-free operation directed towards the need of the patient and users of the system.
- Link and integrate all phases of patient care and support services from the physicians offices and outpatient services, through hospitalization, referral and the financial system, thus creating a comprehensive, totally electronic patient medical record and database.
- Provide a continuously updated knowledge base derived from the opinions of experts, the latest medical literature, accumulated databases along with cost and statistical information that is easily available and accessible in real time to the health care worker.
- Provide computerized decision-making logic for automated monitoring and sophisticated alerting of dangerous and potentially risky situations. This intelligent system would facilitate diagnostic and therapeutic endeavors and provide guidance and direction by standardizing patient care thus fostering quality improvement, cost reduction, and enhancement of outcomes research.
- Function as the foundation of a new style of patient care that is based on quality data, a superior knowledge base, standardization of care, and scientific outcomes research.
- The department will also strive to continually develop the field of clinically-oriented medical informatics by providing educational programs and promoting outcomes research. ⊞

REFERENCES

1. Dick RS, Steen EB, eds. The computer-based patient record. Institute of Medicine. Washington, DC: National Academy Press, 1991.
2. Kuperman GJ, Gardner RM, Pryor TA. HELP: a dynamic hospital information system. New York: Springer-Verlag, Inc. 1991.
3. Gardner RM, Maack BB, Evans RS, Huff SM. Computerized medical care: the HELP System at LDS Hospital. J Amer Health Infor Mgt Assoc 1992;63:68–78.
4. McDonald CJ. Protocol-based computer reminders, the quality of care and the Non-perfectibility of man. N Engl J Med 1976;295:1351–5.
5. Eddy DM. Clinical decision making from theory to practice: the challenge. JAMA 1990;263:287–90.
6. Eddy DM. Clinical decision making from theory to practice: anatomy of a decision. JAMA 1990;263:441–3.
7. Eddy DM. Practice policies: where do they come from? JAMA 1990;263:1265–75.
8. Classen DC, Pestotnik SL, Evans RS, Burke JP. Computerized surveillance of adverse drug events in hospital patients. JAMA 1991;266:2847–51.
9. Pestotnik SL, Classen DC, Evans RS, Stevens LE, Burke JP. Prospective surveillance of Imipenem/Cilastatin use and associated seizures using a hospital information system. Ann Pharmacother 1993;27:497–501.
10. Pestotnik SL. Computer-based alerts for drug dosing in renal impairment. Masters of Science Thesis, Department of Medical Informatics. University of Utah, August 1993.
11. Leape LL, Brennan TA, Laird NM, et al. The nature of adverse events in hospitalized patients—results of the Harvard Medical Practice Study II. N Engl J Med 1991;324:370–6.
12. Evans RS. The HELP System: A review of clinical applications in infectious diseases and antibiotic use. MD Comput 1991;8:282–8.
13. Pestotnik SL, Evans RS, Burke JP, Gardner RM, Classen DC. Therapeutic antibiotic monitoring: surveillance using a computerized expert system. Am J Med 1990;88:43–8.
14. Evans RS, Pestotnik SL, Burke JP, Gardner RM, Larsen RA, Classen DC. Reducing the duration of prophylactic antibiotics use through computer monitoring of surgical patients. DICP, Ann Pharmacother 1990;24:351–4.
15. Classen DC, Evans RS, Pestotnik SL, Horn SD, Menlove RL, Burke JP. The timing of prophylactic administration of antibiotics and the risk of surgical-wound infection. N Engl J Med 1992; 326:281–6.
16. Evans RS, Burke JP, Classen DC, et al. Computerized identification of patients at high risk for hospital-acquired infections. Am J Infect Control 1992;20:4–10.
17. East TD, Morris AH, Wallace CJ, et al. A strategy for development of computerized critical care decision support systems. Int J Clin Monit Comput 1991;8:263–70.
18. Henderson S, Crapo RO, Wallace CJ, East TD, Morris AH, Gardner RM. Performance of computerized protocols for management of arterial oxygenation in an intensive care unit. Int J Clin Monit Comput 1991;8:271–80.
19. Gardner RM. Observations and opinions: collaborations in clinical computing at LDS Hospital. MD Comput 1994;11:1–5.